Aviation and IPv6

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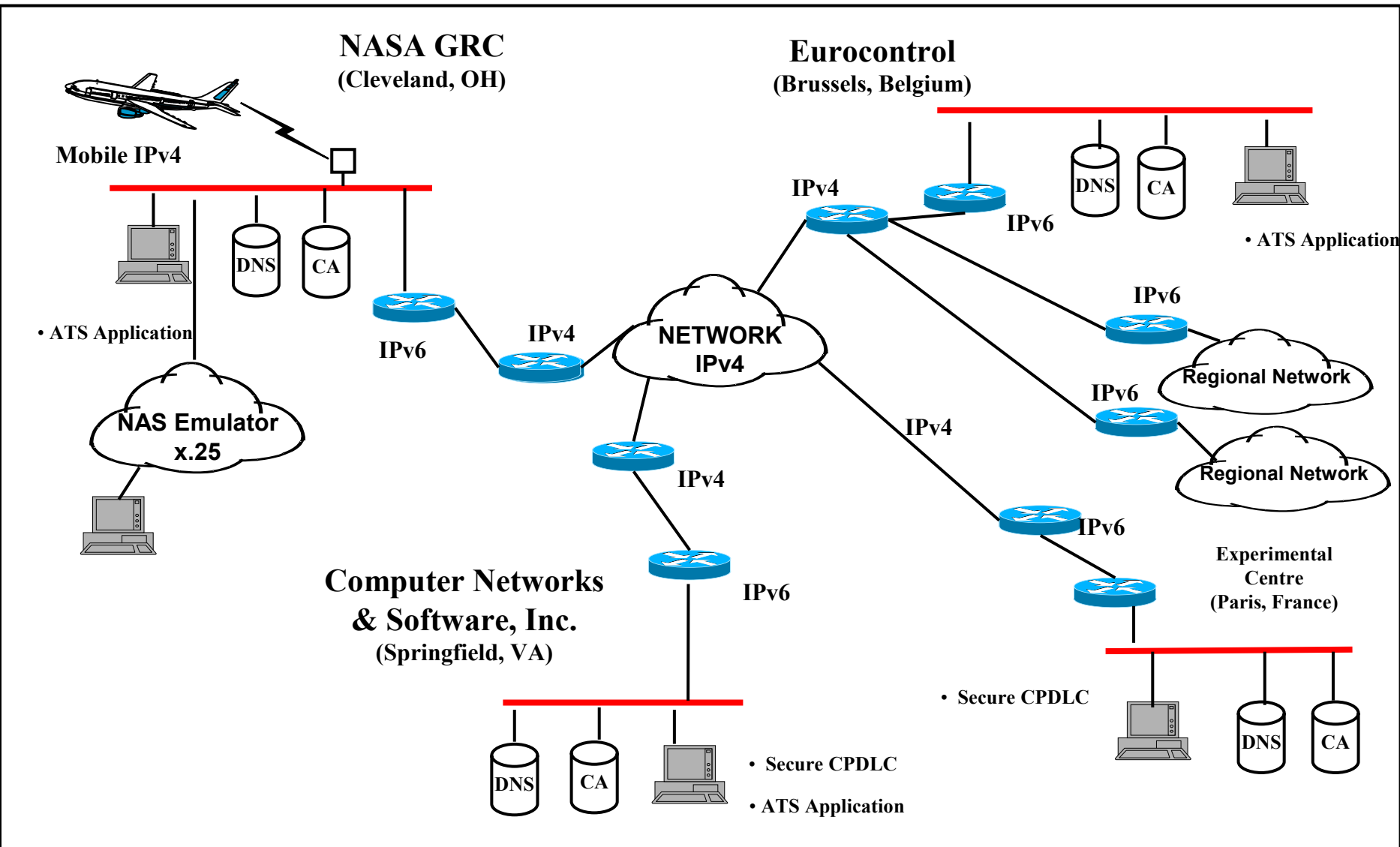Computer Networks & Software, Inc.

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Comptel, Inc.

- **Background & Why IPv6 ?**
- **IPv6 Testbed Architecture**
- **Routing Protocols**
- **VoIPv6**
- **Quality of Service (QoS)**
- **Transition Mechanisms**
- **Conclusions**

Objectives

- Set-up an IPv6 testbed to test and study IPv6 based protocols and its interoperability with ATN and IPv4 networks.
- Leverage mutual IPv6 activities for aviation
  - NASA GRC's R & D in Aeronautical Telecommunications Network (ATN) over IP and work in Mobile IP
  - Eurocontrol's Internet Protocol for Aviation Exchange (iPAX) Project
- Foster IPv6 research and development activities to support International Civil Aviation Organization (ICAO) standardization activities
- Demonstrate ATN related services over IPv6: e.g., Controller to Pilot Data Link Communications (CPDLC), On-Line Data Interchange (OLDI)

CNS

NASA GRC
(Cleveland, OH)

Eurocontrol
(Brussels, Belgium)

Mobile IPv4

IPv4

DNS   CA

• ATS Application

IPv4

IPv6

• ATS Application

IPv6

IPv6

NETWORK
IPv4

Regional Network

IPv4

IPv6

DNS   CA

NAS Emulator
x.25

Regional Network

IPv6

IPv4

IPv6

Experimental
Centre
(Paris, France)

Computer Networks
& Software, Inc.
(Springfield, VA)

IPv6

• Secure CPDLC

DNS   CA

• Secure CPDLC

• ATS Application

DNS   CA

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- High Scalability
  - 128-bit addresses allows 3.4 x 10 ^ 38 addresses
- Improved support for QoS, mobility – Desired for ATN
- Built in IP Security
- Fixed Length Header
- Internet Protocol for the future
  - In US, DoD plans to move to an all IPv6 network by 2008
  - In Europe, iPAX is investigating ways to move from X.25 networks to IPv6 based networks

IPv6 Test-bed Architecture
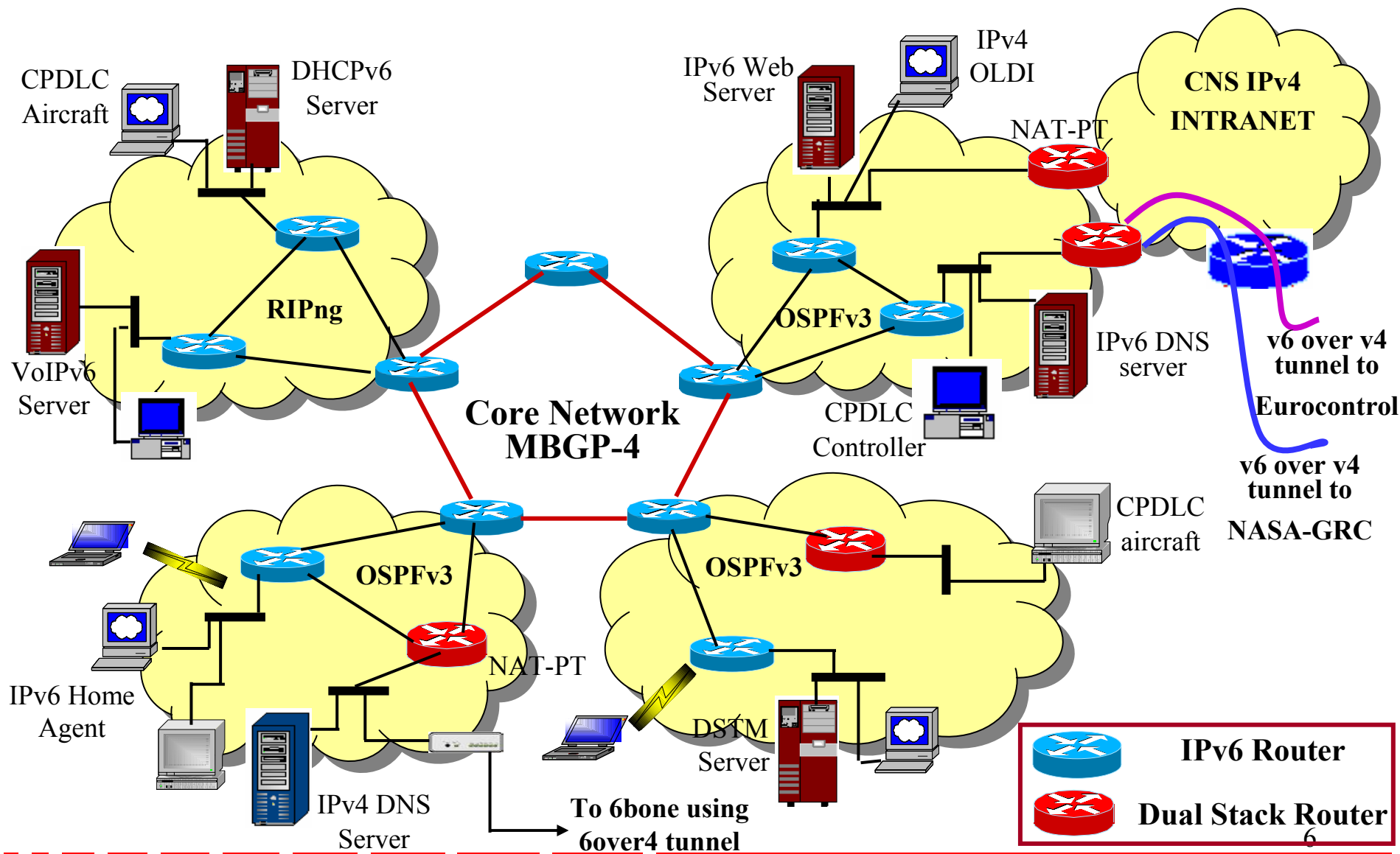
- Similar to IPv4 based routing in CIDR – *longest prefix match*
- Routing Domain
  - Interior Gateway Protocol (IGPs)
    - » OSPFv3, IS-IS for IPv6, RIPng
  - Exterior Gateway Protocol (EGPs)
    - » MBGP-4

- Basic OSPF algorithm, mechanism and packet types remains the same

- Updated features for OSPFv3
  - Runs over a link than over a subnet
  - Distributes IPv6 prefixes
  - Flexible handling of unknown Link State Advertisements (LSA)
  - Addressing semantics are removed
    - » IPv6 address not present in most OSPF packets

- RFC 2283 defines extensions to the BGP protocol to carry routing information for other protocols (CLNS, IPv6, IPx, …)

- Defines two new attributes
  - Multiprotocol Reachable NLRI
    » Carries the set of reachable destinations together with the next hop information
  - Multiprotocol Unreachable NLRI
    » Carries the set of unreachable destinations

- IPv6 specific extensions for MBGP defined in RFC 2545
  - Address Family Identifier AFI = 2 (for IPv6)

- Advertised next hop addresses contain a global IPv6 address and a link local address

VoIPv6

- SIP and H.323 based signaling for establishing Voice over IPv6 calls
- SIP and IPv6
  - Text based protocol
  - True internet based, scalable, extendable to other IP capable devices (e.g. gaming devices)
  - Dynamic configuration of end systems (user agents) and load balancing
  - Use of Anycast by user agents to send all SIP messages to registrar /outbound proxy
- SIP over IPv6 implementation for Linux
  - SIP Express Router (SIP registrar server, proxy)
  - Linphone and BonePhone (IPv6 User agent)

- Air Traffic Services require different QoS features
  - Bandwidth
  - End-to-end delay
- Proper resources distribution is required
- We implement a framework for providing QoS for three different aviation applications
  - CPDLC
  - Surveillance
  - User Data

4-Bit Version	8-Bit Traffic Class	20-Bit Flow Label

Two main QoS mechanisms

- IntServ
  - » QoS per connection
  - » Makes use of the Flow Label field
  - » Poor Scalability
- DiffServ
  - » QoS by packet type/tag
  - » Makes use of the Traffic Class field
  - » Excellent Scaling properties

IPv6 DiffServ

- Classifies packets into behavior aggregates
- First six bits of the Traffic Class field, know as DiffServ Code Point (DSCP), map to a unique Per Hop Behavior (PHB).
- Following PHB's have been standardized by IETF
  - Expedite Forwarding (EF)
    - » Low loss, Low delay, Low jitter
    - » Appears as a virtual leased line.
  - Assured Forwarding (AF)
    - » Traffic within the subscribed rate is served with high level of assurance
    - » Four AF classes are defined (AF1, AF2, AF3 and AF4)
    - » Each class supports three drop precedence (AF1x, AF2x,AF3x, AF4x)
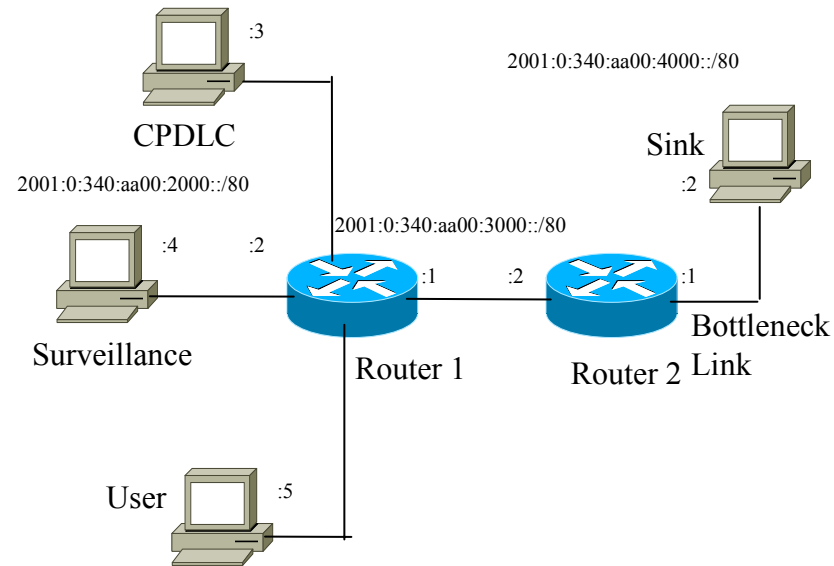 - Best Effort (BE)
    - » Does not guarantee any bandwidth

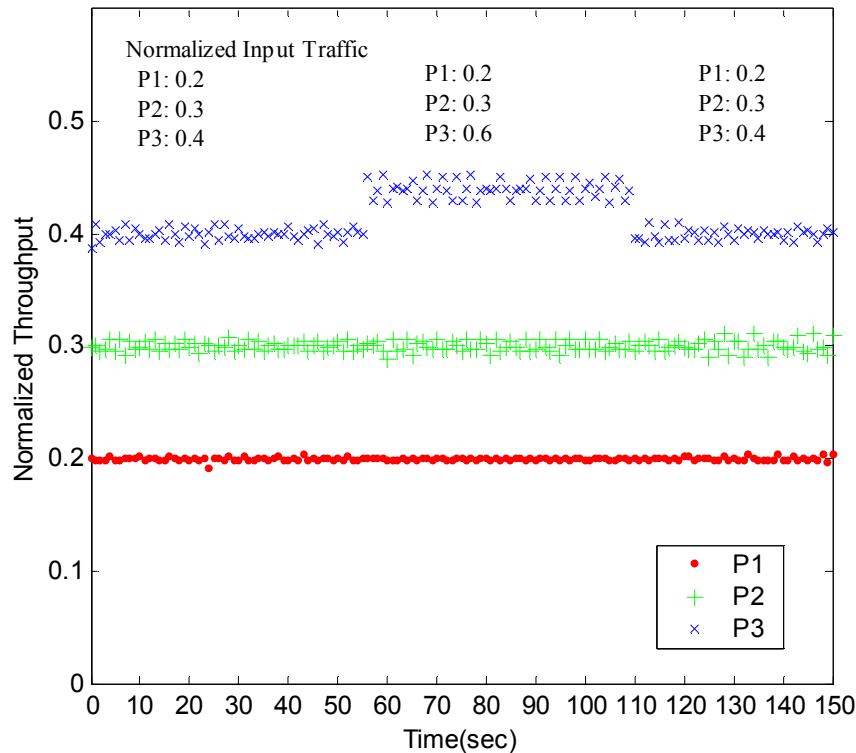- Linux routers with *traffic control* tool for DiffServ mechanism

  - Router 1
    - Performs classification
      » CPDLC traffic (P1) into EF PHB
      » Surveillance traffic (P2) into AF11 PHB
      » User traffic (P3) into BE PHB

  - *Router 2*
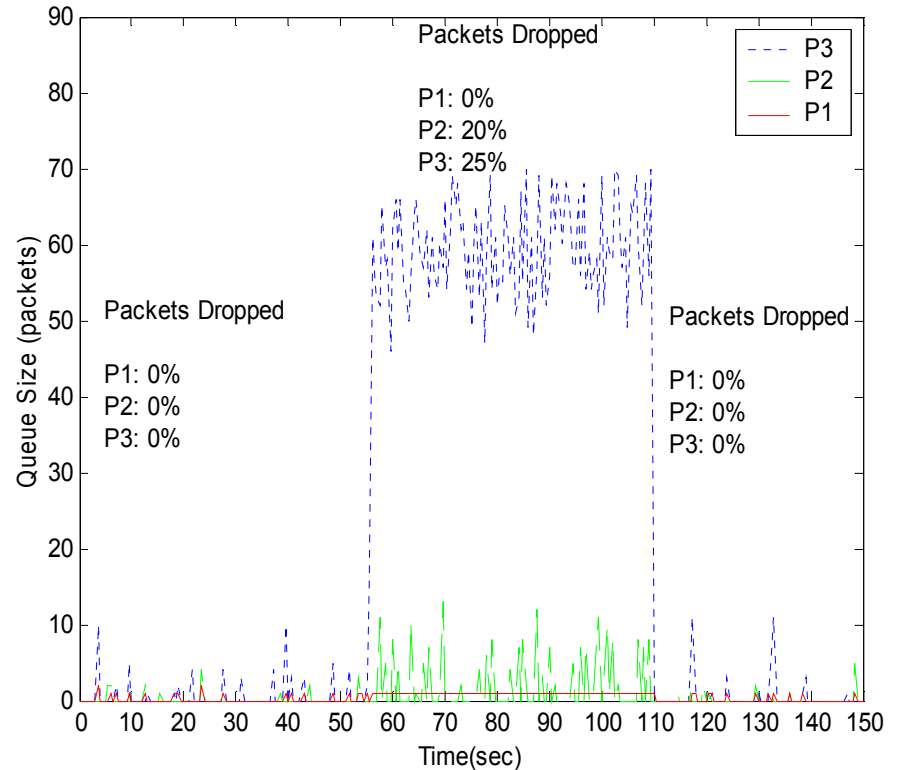   - Performs queuing and scheduling
      » EF class traffic: PFIFO queue & 20% b/w
      » AF class traffic: GRED queue & 30% b/w
      » BE class traffic: RED queue *& 50% b/w*

    - Under congestion higher class traffic borrows b/w from the lower class
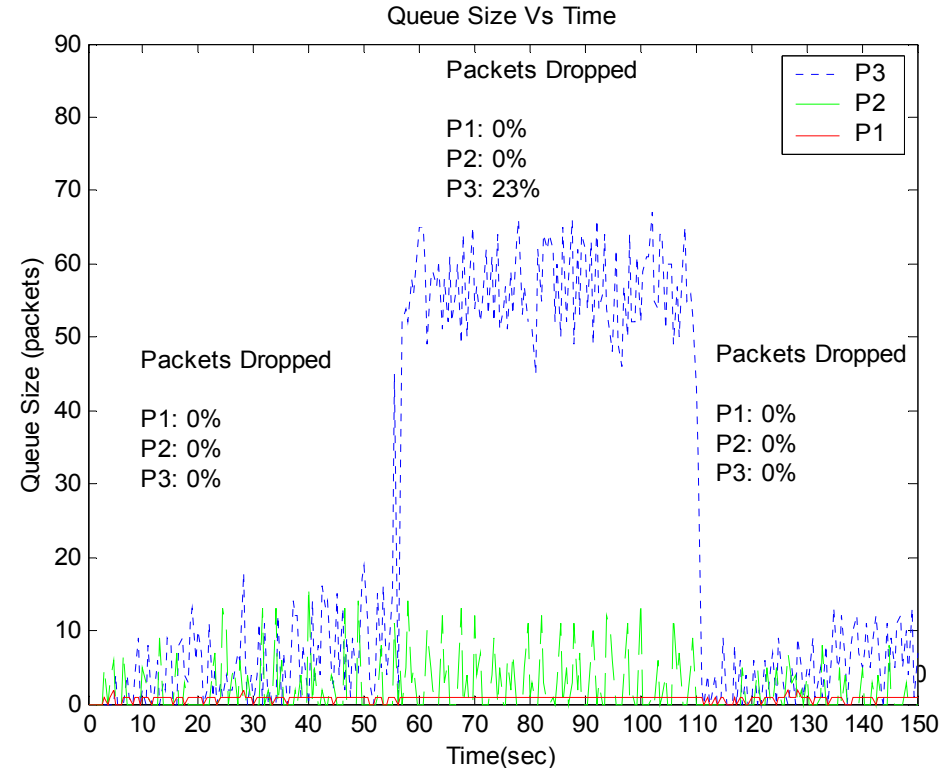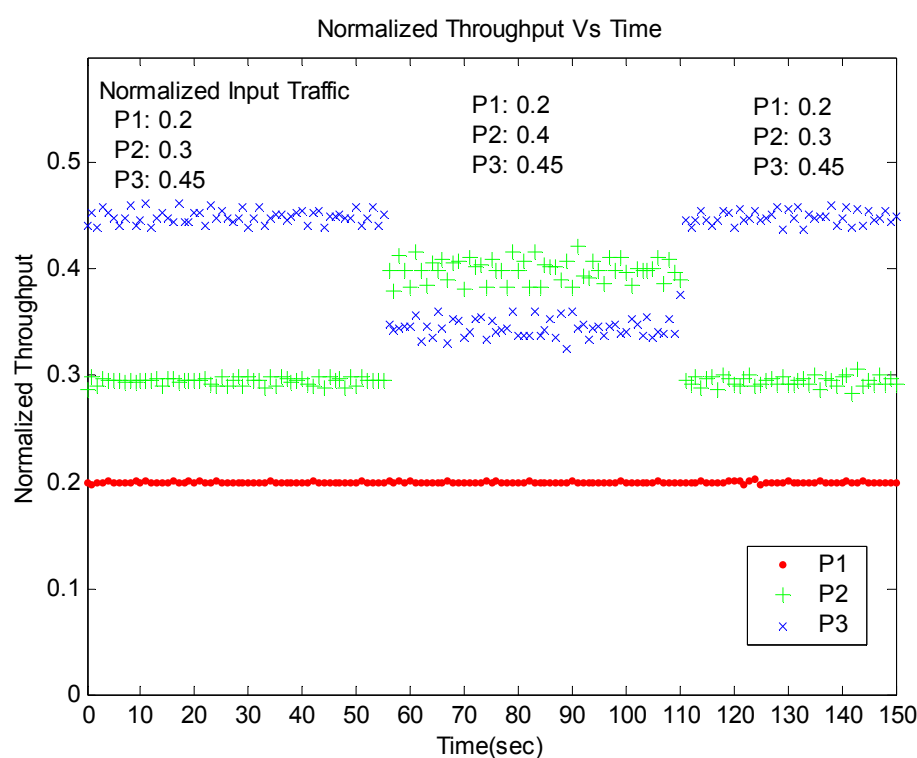

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Normalized Throughput Vs Time

Normalized Input Traffic
P1: 0.2   P1: 0.2   P1: 0.2
P2: 0.3   P2: 0.3   P2: 0.3
P3: 0.4   P3: 0.6   P3: 0.4

Queue Size Vs Time

Packets Dropped
P1: 0%
P2: 20%
P3: 25%

Packets Dropped

P1: 0%
P2: 0%
P3: 0%

Packets Dropped

P1: 0%
P2: 0%
P3: 0%
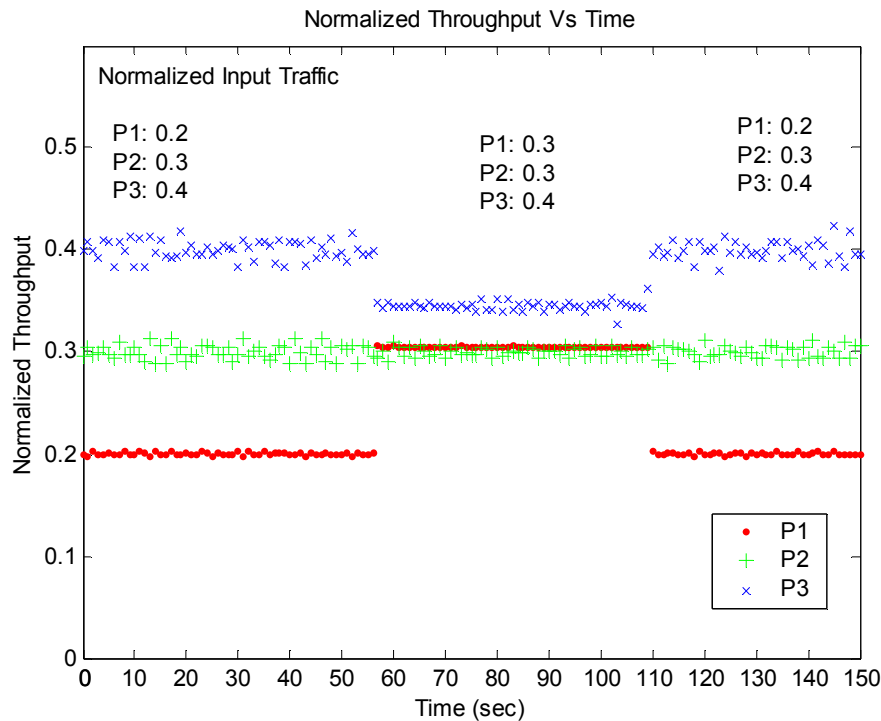
Congestion due to increase in user data traffic (P3) results in large packet loss for BE traffic class (25%)

Normalized Throughput Vs Time

Queue Size Vs Time

- Congestion due to increase in surveillance traffic (P2) results in AF1 class borrowing bandwidth from BE class.
- Performance degrades for BE traffic class (23% packet loss) while there is no affect on EF and AF1 traffic classes.

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Normalized Throughput Vs Time

Queue Size Vs Time
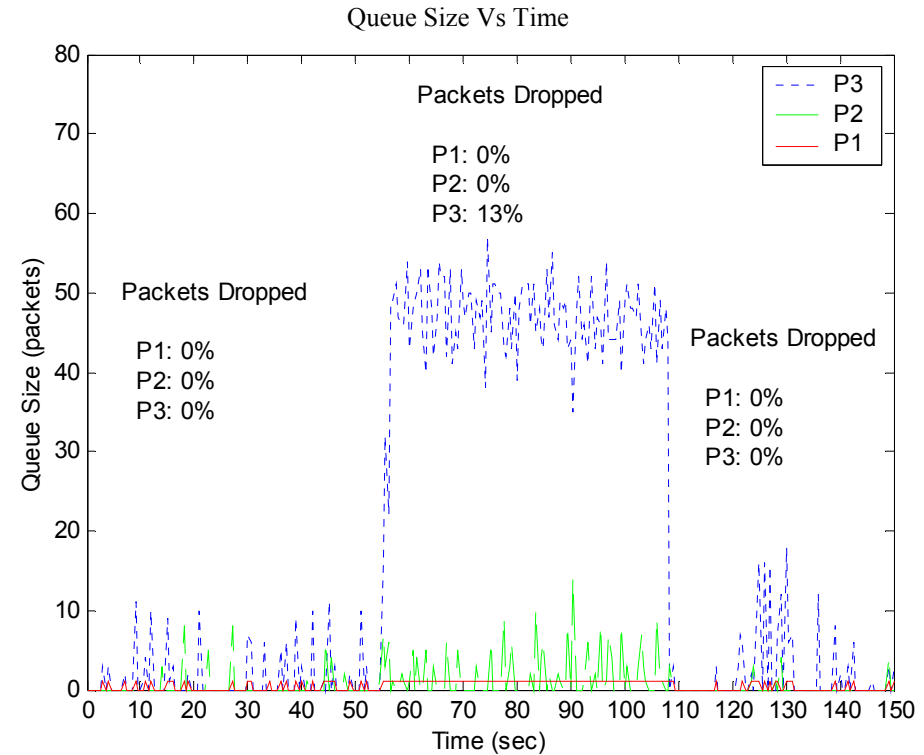
- Congestion due to increase in CPDLC traffic (P1) results in EF class borrowing bandwidth from BE class.
- Performance degrades for BE traffic class (13% packet loss) while there is no affect on EF and AF1 traffic classes.

- Current ground network is based on OSI and IPv4

- Integration of IPv6 to the existing network should be seamless

- The transition to IPv6 will be gradual with these protocols co-existing for several years

- A number of transition tools available for addressing different scenarios

- Dual Stack
  - IPv4/IPv6 or OSI/IPv6 protocol stacks exist on the same device
- Translation
  - Provides translation between IPv4 and IPv6 protocol headers
  - Can be used either at network, transport, or the application layer
- Tunneling
  - Encapsulates the packets of one protocol into the payload of another protocol
  - Two types
    - » Static Tunnels
    - » Dynamic Tunnels

Network Address Translator- Protocol Translator (NAT-PT)
(RFC 2766)

- A stateful translation mechanism at the network layer that allows communication between IPv6 only hosts and IPv4 only host
- Makes use of SIIT algorithm for translation
- Two variants
  - Basic NAT-PT
    - » Uses a pool of IPv4 addresses to bind an IPv6 address to one of the IPv4 address in the pool
  - NAPT-PT
    - » Allows several IPv6 addresses to multiplex onto a single IPv4 address by using port mapping
- Needs Application Level Gateway (ALG) for some upper-layer protocols such as such as FTP and DNS
- End-to-end network layer security is not possible - Limitation
- Supported in Linux, FreeBSD, Cisco, Microsoft
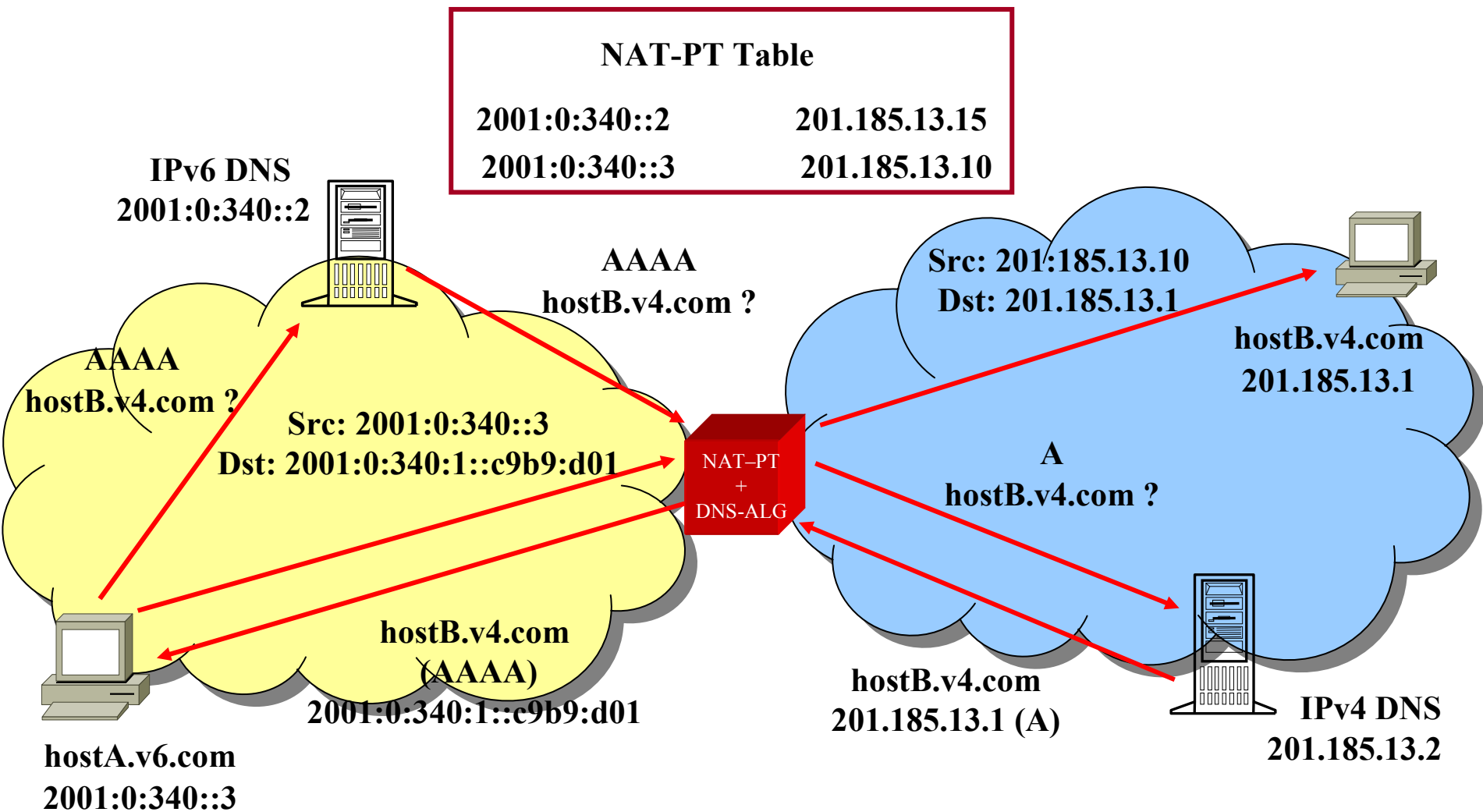
- Transport Relay Translator (TRT) (RFC 3142)

  A transport level translator that relays connection at the border between IPv4 and IPv6 domains.

- Bump In Stack (BIS) (RFC 2767)

  Translator resides within the host. Allows IPv6 applications to run on IPv4 host.

- Bump In Application (BIA) (RFC 3338)

  Uses an API translator between the socket API and host stack's TCP/IP module. Removes the need for IP header translation

- Socks64 (RFC 3089)

  Allows application level IPv6-IPv4 translation by using dedicated SOCKS server for relaying flows between IPv4 and IPv6 hosts

6to4 (RFC 3056)

- A mechanism for isolated IPv6 islands to communicate with each other over the IPv4 network without explicit tunnel setup

- Native IPv6 domains communicate via 6to4 routers which has one globally routable IPv4 address

- Embeds the IPv4 address of the router in a 6to4 16-bit prefix (2002::/16)

- Example

    6to4 router *IPv4 address: 202.185.12.4 = cab9:0c04*

    6to4 48-bit prefix: 2002:cab9:c04::/48

- Supported by Linux, FreeBSD, Microsoft and Cisco

CNS

IPv4 address: 202.185.12.4
6to4 prefix: 2002:cab9:c04::/48

IPv4 address: 203.185.12.2
6to4 prefix: 2002:cbb9:c02::/48

IPv6

Src: 2002:cab9:c04::c32:34
Dst: 2002:cbb9:c02::e562

Src: 202.185.12.4
Dst: 203.185.12.2

6to4 tunnel

IPv4

IPv6

Src: 2002:cab9:c04::c32:34
Dst: 2002:cbb9:c02::e562

Host A
2002:cab9:c04::c32:34

Host B
2002:cbb9:c02::e562

Dual Stack Transition Mechanism (DSTM)
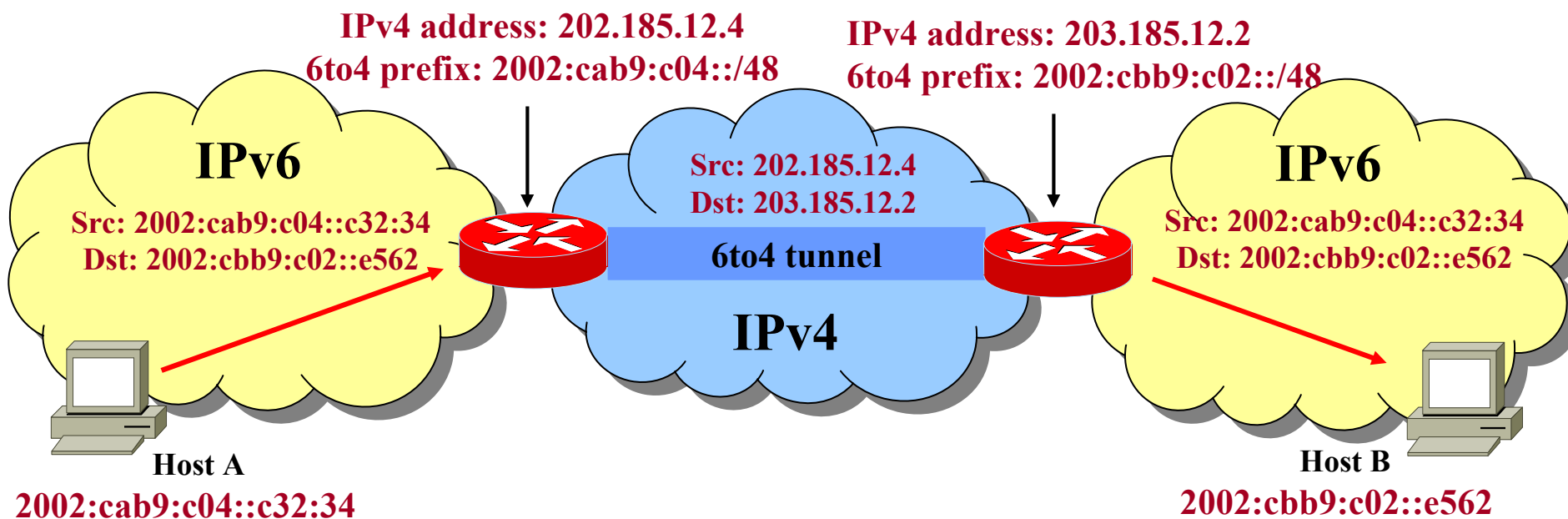
- Uses IPv4-over-IPv6 tunnels to carry IPv4 traffic within an IPv6-only network
- Specifies a method for
  - IPv6 nodes to communicate with IPv4-only nodes
  - IPv4-only applications to run on an IPv6 node
- Avoids Network Address Translation by assigning temporary IPv4 addresses to dual stack nodes using IPv6
- DSTM architecture comprises of
  - DSTM Server: Allocates temporary IPv4 address and specifies TEP address
  - DSTM node: Dual Stack node capable of creating 4over6 tunnels to the TEP
  - DSTM gateway: Border router between the IPv6-only domain and an IPv4 internet
- Supported by Linux and Free BSD

DSTM Server

Requests an IPv4 addr. and TEP addr.

10.1.1.20

TEP: 2001:0:340::1002

DSTM Border Router

Host B

4 over 6 tunnel

IPv6

IPv4

Host A

2001:0:340::1001

2001:0:340::1002
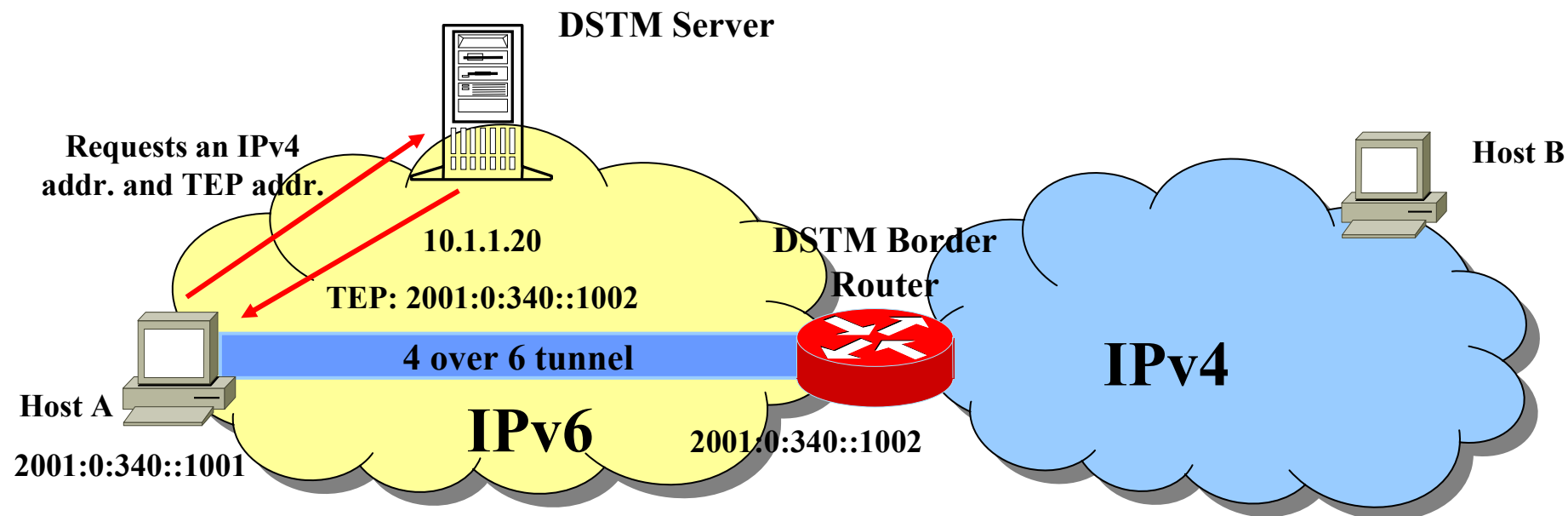
- Intra Site Automatic Tunnel Addressing Protocol (ISATAP)

    Allows IPv6 hosts to communicate within a IPv4 intranet

- 6over4 (RFC 2529)

    Provides a solution to scenarios where a number of IPv6   hosts
    are scattered around in an IPv4 domain, and none of them have a
    direct IPv6 connectivity. Isolated IPv6 hosts create their own tunnel

- Tunnel Broker (RFC 3053)

    Uses dedicated servers, called Tunnel Brokers, to automatically
    manage tunnel requests coming from isolated IPv6 sites.

- Teredo

    Proposes a mechanism to tunnel packets over UDP to provide IPv6
    connectivity to IPv6 nodes located behind one or several NATs.

- Presented the IPv6 testbed architecture and inter-connection between CNS, NASA-GRC and Eurocontrol domains

- Presented an overview of IPv6 routing protocols and VoIPv6

- Implemented and analyzed the initial framework for providing QoS using DiffServ for different air traffic services

- Discussed the various mechanisms for transitioning to IPv6 networks